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ABSTRACT

Solutions to many of the great problems facing society will be found through interdisciplinary research, and environmental problems are a prime target for such an approach. In tackling these problems, it would be a great mistake, however, to weaken the classical disciplinary departments. More than 60 new chemistry departments were created since 1960; in June 1969, these granted only 140 Ph.D.'s as opposed to the 1,800 Ph.D.'s granted by the earlier established, 125 departments. There seems to be no need for establishing new chemistry departments, except perhaps for geographical reasons. Chemistry faculty at 4-year institutions should be given more opportunity for leave, and technicians should be used in the conduct of research. In terms of the science curriculum, there is need for greater flexibility and for encouraging Ph.D.'s to develop greater awareness of peripheral fields. As for scientific manpower needs in industry, inflation and rising costs have forced a reduction in recruitment. Improved business conditions will change this picture. (AF)

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# THE OUTLOOK FROM CHEMISTRY*

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DR. T. L. CAIRNS: Dr. Rees, Ladies and Gentlemen: I assure you I feel very much like an outsider in this group, perhaps because that's what I am. (Laughter.) My experience with graduate schools in this country has been exceedingly limited, even in the field of chemistry. I have seen almost nothing of other scientific disciplines in engineering, and I think absolutely nothing in the humanities. So it is with great diffidence that I make any remarks at all.

Dr. Pelczar gave me a bit of an opening by reading out of the newspaper and I thought I would start off the same way, to make a very simple point. This is now a quote:

"In some quarters a senseless fear of science seems to have taken hold. We hear the cry that there should be a holiday in scientific research and in the new applications of science, or that there should be a forced stoppage in extension of old usages by mandatory legislation."



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That takes care of that point.

On the job situation, this is now a quote from a letter written by the head of a department. I am paraphrasing this only to the extent of leaving the actual name of the school out: "I haven't the faintest idea of where your former student can get a job. Our department is filled with our own Ph.Ds hoping for a small stipend. It is a shame that these able men should be without positions. I am hoping that conditions will improve soon."

Well, I chose to read that and I was impressed that it sounded not unlike what Dr. Pelczar read. Both these quotes were written in 1932.

(Laughter.)

My point simply is that times have been bad before and they have gotten better. When times are bad, institutions are attacked. I think that has been true throughout all of history. And science is an institution, universities are institutions, and so is the Federal Government.

Well, I would like to make some brief comments. I want first to talk a minute about one aspect of this question of interdisciplinary research in the universities. I want to say a word about the absolute



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numbers of Ph.D. granting institutions, and Dr. Rees did touch on that; and then to finish up by combining a few words about changes in curricula, along with the needs of industry.

On the question of interdisciplinary research, it is certain in my opinion that many of the current problems of great impact on society are going to find their solutions in truly interdisciplinary research. The environment let me take as an example; it is one of several.

The problem of environmental improvement is certainly one where progress will be made through an interdisciplinary attack.

The thing that I am frequently impressed with in discussing these problems with my own colleagues in industry, and also in the universities, is that there is a certain tendency to forget that a photochemical smog is made up of molecules; these molecules are still made up of atoms; they still obey some of the laws which Dr. Alberty used to teach in elementary physical chemistry. And, of course, they still are subject to the laws of meteorology.

It seems to me when we are concerned with



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an interdisciplinary attack, we are talking about solving a problem by using the most advanced knowledge available in the classical disciplines. I can't quite see how today there is such a thing as an environmental scientist who hasn't first been an outstanding chemist or an outstanding biologist, an outstanding engineer of some kind.

(Applause.)

I think interdisciplinarity is for the older folks--I mean over 30 perhaps.

(Laughter.)

I don't feel this way at all, of course, about the teaching at the undergraduate level in course work of general science, survey courses are problems of the environment. I think they can be made exceedingly interesting and exciting courses at both the undergraduate and graduate levels, but when you talk about attacking the problem, you are talking about applying the best knowledge from the existing disciplines. This leads me to feel that if universities attack, let us say, the problem of environmental improvement, they are going to have to try to solve some of the problems, they are going to have to attack a problem, and I think they are going to have to do this with their own hands, with post-doc assistance, and only



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to a very limited degree using that as an educational experience for graduate students.

Part of my plea here is that as we move to the support of interdisciplinary activity in the universities, I believe it would be a great mistake to do that by weakening the classical disciplinary departments.

I am very much in favor of the physicists talking to the chemists and working with the chemists, but I still think there are forefronts in these fields which it is in the national interest that we have excellent men exploring them.

I want to turn now to this question of the numbers of Ph.D. granting institutions, and my remarks here are strictly limited to chemistry, chemistry departments; these are the only ones in which I have any data, and in these comments I am drawing on a report published by the National Research Council last month, reporting on the annual meeting which was held last March, and by and large most of this data has been collected by an A.C.S. committee headed by Chevis Walling of the University of Utah.

I am impressed with the integrity of this group, so I think some of these numbers are really factual.



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(Laughter.) There have been about ten new Ph.D. granting institutions in chemistry formed, came into existence, each year for the last ten years. The number went from 125 in about 1960 to something a shade over 180.

It is a very expensive undertaking, and perhaps this carrying coals to Newcastle, it is a very expensive undertaking to establish a new Ph.D.-granting department.

There were 1,900 Ph.Ds granted in June of 1969 in chemistry and 1,800 of these were granted by the 125 schools that existed prior to 1960. Only 140 of the 1,900 were granted by the 60 schools organized since 1960. The arithmetic works out that the old institutions, the prior-to-1960 institutions, in 1969 averaged 14 Ph.Ds granted per institution, while the 50 new institutions averaged 2.8. This, to me, proves that establishing a new Ph.D. program is a very, very difficult thing to do.

Now, the main point I was leading up to here comes from these numbers as background with this additional figure: In these 180 or 185 schools granting Ph.Ds in chemistry, there are 3,700 qualified faculty and this 3,700 qualified faculty granted 1,900 doctorates

in '69. This comes out to about an average of about 0.5, or one-half Ph.D. per qualified faculty member per year.

Considering the problems of financing the universities, the Federal problems, it seems to me that a good argument can be made that for the immediate future--perhaps five, maybe longer years--it is unlikely that we need more Ph.D.-granting institutions in chemistry. There are distinguished professors of chemistry who have averaged, over a working lifetime, substantially more than one-half Ph.D. per year. If you could just even bring that to one Ph.D. per year, this would then mean that we have the physical facilities, we have the plant, we have the faculty to double the production of Ph.Ds in chemistry. And I think it is a little unlikely that in the immediate future we would need to double them.

There are, of course, many easily understood driving forces that leads a four-year institution to want to add a Ph.D. program. I won't enumerate those; I want to comment on just one.

I don't really believe today there is any geographic justification which can be used any longer. This is certainly true, in my opinion, for full-time



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students. It may be there is a geographic justification for graduate programs in chemistry in some areas where part-time students need that opportunity. That's a point I have not seen properly investigated.

Well, if I am urging that four-year institutions in chemistry should remain that, there are, I think, things that can be done to strengthen them, rather than just put a lid on them. I think that it is--would be exceedingly desirable to handle the four-year institutions in science and chemistry particularly, by arrangements for many more leaves for faculty on a much more frequent basis as part of the cost of doing business, if I may use that expression.

I think that the building up of a technician staff to help in the conduct of research would also be desirable; and I would also like to see a strong tendency toward more post-doctoral appointments so that faculty in four-year colleges can, in fact, get something constructive accomplished in research.

Well, I would like to finish up by kind of combining a few points on curriculum and the needs of industry.

Certainly the curriculum and the changes



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in it is a continuing study, a continuing problem. I have seen it estimated several places that the substantive half life content of a course in physical science is about seven years. So every seven years half of what is being taught wasn't known or was not in the course seven years ago.

On the other hand, I think that the details of a curriculum are very much less important than the atmosphere and attitude in which the graduate student is brought up.

I believe that it has been frequently stated, and it is part of my own experience, that the recent Ph.Ds--on the average again--really need a greater degree of flexibility in their outlook toward science and toward chemistry than we have frequently seen.

If I may illustrate this with a minor anecdote with a boy I interviewed about five years ago--and times have changed only a little in five years, really. He was a very good man, we had seen his records, we knew about him before he came out looking for a job. I asked him what he wanted to do. He said, "I want to work on the active side of chymotrypsin." This was his thesis subject.



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I said, "Well, that's a great subject. How would you like to work on the active side of some other enzyme?"

He said, "No."

I said, "Well, we're not working on chymotrypsin. We do have a program on the enzymatic fixation of nitrogen. We have crystalized the nitrogenase. Would you work on the active side of this?"

He said, "No."

Well, I thought he was a good enough man that we made him a formal offer where it was specifically spelled out that he would not work on the active side of chymotrypsin and he refused our offer. I am planning to look him up--it is about four years ago now--and see if I can find what he is working on.

(Laughter.)

This to me is not what I have in mind when I talk about Ph.D. education. I think the new Ph.D. should be encouraged to develop an awareness of peripheral fields. I hope they can develop an eagerness to solve problems and not just to assign data.

And most importantly of all, I hope the new Ph.Ds will come out with a really well developed



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self-confidence in their own ability to master a new subject, to become involved and interested in a new topic.

Well, to turn finally to the manpower needs in industry, there is certainly a great deal of confusion about this.

It is accentuated at the moment by poor business conditions and the terrible anecdotes in which the taxi driver was mentioned this morning.

I could add one of my own; we had a man resign last week, a Ph.D. and physicist, to make movies. He is making mod movies and he thought he could do that better than physics. So I guess that's all right.

I think I would like to take a slightly longer range point of view. The supply of scientists and engineers has been increasing by some rather steady percentage--I am sure Dr. Falk would know--it is about six percent since 1700, I believe, and except for short-term discontinuities, this has held fairly constant. I think we are in the midst of a short-term discontinuity from industry's point of view right now. And while our own company has tried very hard to resist the short-term pressures so that we have a continuing recruiting program, and a consistent one so that we don't develop a technical



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staff with gaps in it, I must say the pressures in the past two years have been exceedingly difficult; difficult enough that we have reduced our recruiting in 1970, and it will be done again in 1971.

I hope you don't think I am just shedding tears and looking for sympathy, but I would like to illustrate how inflation has affected our company in one specific way.

I saw in the paper this morning that the wage rate inflation in the construction industry was 7.8 percent for the past 12 months. Our construction figure this year which has been published is about $480 million. If one takes just that inflation figure for wage rates alone, in just our construction, leaving out our manufacturing and research, this comes out to about between $50- and $60,000 per day added cost to duPont. Now, that is just about what it costs us to hire a Ph.D. and keep him for a full year.

So in the past 12 months we have lost, hard cash, what would have been the equivalent of hiring 365 Ph.Ds--for one year, that is. But that is only one part of the cost of doing business and I thought it was perhaps worth mentioning to illustrate how difficult it



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is for industry to take the real long range point of view.

We are quite confident that our recruiting will go up, our needs will go up as our business goes up, but it has been an exceedingly difficult time.

My own immediate concern is that the supply, as a consequence of all the pressures you have heard about today, the anti-science attitude, the reduction in Federal funds, the blaming of the environmental problems on science and technology, the urgent political need for good people to go into that field and solve some of the other social problems, I am afraid that all of this will lead to a very substantial dropping off in registrations in science and engineering and we may find ourselves, not with an excess only a few years from now, but rather, a great shortage of really well-trained, well-educated Ph.D. scientists and engineers.